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Neutrosophic Classification of the Factors That Shape the Professional Profile of Students in Ecuadorian Higher Education

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Abstract. This article examines the professional profile of university students in the context of uncertainty of Ecuador. What constitutes this professional profile? Technical skills? Soft skills? Demands of the international and national market? This is relevant to the nation because the employability situation of the country depends on economic development. The correlation between higher education and economic development has been complicated by developments that exploit imperfectly educated people for demand within the employment market. Thus, a professional profile is neither the first study of such developments; however, few studies exist that assess the professional profile through uncertainty and contradiction which means that the perceptions of students/teachers/employers are too uncertain to provide a holistic picture. Therefore, neutrosophic set theory is applied to fill the gap, which means that for each factor derived, assessed via neutrosophic sets through various degrees of belonging, uncertainty/indeterminacy, and non-belonging, classification is based on strongness. Ultimately, the results showed that the highest levels of indeterminacy were found for technical skills and soft skills which means that coursework should more intensely integrate such aspects of university life/professional profile. This study contributes to the field by providing a new theoretical application to an uncertainly complicated field of study which will allow for universities and their corresponding segments to know what's best for future curriculum to cement the professional profile. It will also lend to suggestions for implementation—from curricular adjustments to supportive productive sector requirements—to better prepare students for entry into a complicated and ever-evolving labor force.

Keywords: Neutrosophic Sets, Professional Profile, Higher Education, Uncertainty, Competencies, Employability, Ecuador.

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1. Introduction

The development of the professional profile of students in Ecuadorian higher education constitutes a fundamental pillar for the country's economic and social development, given that the preparation of graduates directly impacts their employability and the competitiveness of the labor market. In a dynamic global context, where labor demands evolve rapidly, universities face the challenge of aligning their educational programs with the needs of the productive sector [1]. The importance of this issue lies in its capacity to reduce the gap between academic training and market expectations, a critical aspect in emerging economies such as Ecuador [2]. Recent studies emphasize that professional profiles must integrate technical competencies, soft skills, and practical experiences to ensure a successful transition to the workforce [3]. This article explores the factors that shape this profile, employing an innovative approach based on neutrosophic set theory to address the uncertainties inherent in this process.

Historically, higher education in Ecuador has undergone significant reforms, especially since the implementation of the Organic Law on Higher Education in 2010, which sought to improve the quality and relevance of training [4]. However, challenges persist, such as the disconnect between curricula and labor market demands, which limits student preparation [5]. In recent decades, the country has made progress in accrediting universities and promoting community engagement programs, but conflicting perceptions among students, teachers, and employers about the necessary skills generate ambiguity [6]. This historical and current context highlights the need for analytical approaches that consider complexity and uncertainty in vocational training.

The central problem addressed by this research is the lack of clarity regarding how key factors, such as technical competencies, soft skills, and internship opportunities, contribute to shaping the professional profile of Ecuadorian students. How can these factors be classified, considering the ambiguous and contradictory perceptions of the stakeholders involved? The magnitude of this problem is reflected in youth unemployment rates and the underutilization of skills in the Ecuadorian labor market, which demands an analysis that integrates the uncertainty present in the assessments [7]. This study seeks to answer this question through an approach that allows for systematic modeling and classification of factors. Neutrosophic set theory offers a powerful tool for addressing this problem, as it allows for the representation of the belonging, indeterminacy, and non-belonging of each factor, thus capturing the ambiguity inherent in the perceptions of students, teachers, and employers. Unlike traditional approaches, which typically assume precise data, this method incorporates uncertainty as a core component of the analysis [8]. By classifying factors according to their impact on professional profiles, the study aims to identify priority areas for educational intervention. This approach is particularly relevant in a context where labor market expectations and graduate capabilities are not always aligned.

The objectives of this research are clear and aligned with the research question. First, it seeks to identify and classify the factors that shape the professional profile of university students in Ecuador using neutrosophic sets. Second, it aims to propose strategies based on the results to optimize professional development, such as curricular adjustments or training programs. Finally, the study aims to contribute to the development of a theoretical and methodological framework that can be applied in other educational contexts with similar characteristics.

2. Preliminaries

2.1. Complexity theory and causality and neutrosophic sets

Interactions between variables are not always simple; rather, they frequently emerge through intricate, nonlinear patterns, as complexity theory posits. This perspective tells us that the same cause can lead to divergent outcomes depending on the context in which it manifests. This theory emphasizes

three key principles: conjunction, equifinality, and causal asymmetry. The conjunction principle focuses on the collaboration between antecedent conditions that act together to produce an outcome, rather than operating independently to explain variability. Equifinality, on the other hand, posits that a system can reach a specific end state through a variety of initial conditions and distinct trajectories. Causal asymmetry, on the other hand, suggests that while certain conditions can lead to the emergence of an outcome, their absence does not guarantee the absence of that outcome [9].

To illustrate this, consider a restaurant renowned for its high culinary quality. Although this quality may attract numerous customers, the establishment might face low attendance due to factors such as an unfavorable location or parking issues [10]. Conversely, a restaurant with average food might still attract many customers if it offers exceptional service, is in a strategic location, or has attractive entertainment options. This demonstrates that the relationship between variables such as the quality of food, location, and service, and the outcome—the number of customers—is by no means simple or constant. These principles highlight the complexity and lack of stability in the relationship between conditions and outcomes. Furthermore, neutrosophy brings greater depth to the understanding of complex causality by introducing indeterminacy and uncertainty, which are inherent to social phenomena. Neutrosophic set theory, with its ability to handle indeterminacy, provides a more nuanced perspective for understanding these complex and dynamic relationships [11].

2.2. Neutrosophic Liker scales

Surveys using neutrosophic Likert scales [12, 13, 14] effectively measure the diversity of opinions and their influence on public policy and social discourse, capturing areas of consensus, disagreement, and ambivalence.

Below we present the fundamental definitions and concepts related to neutrosophic sets and single-valued neutrosophic sets .

Definition 1 ([15]). Let U be a discursive universe. $N = \{(x , T (x), I (x), F (x)): x \in U \}$ is a neutrosophic set, denoted by a truth membership function, $TN : U \rightarrow]0 - , 1+[$; an indeterminate membership function , $IN : U \rightarrow]0 - , 1+[$; and a falsehood membership function , $FN : U \rightarrow]0 - , 1+[$.

Single-valued neutrosophic sets provide a way to represent and analyze possible elements in the universe of discourse U

Definition 2 ([16]). Let U be a discursive universe. A single-valued neutrosophic set is defined as $N = \{(x , T (x), I (x), F (x)): x \in U \}$, which is identified by a truth membership function, $TN : U \rightarrow [0, 1]$; indeterminacy membership function , $IN : U \rightarrow [0, 1]$; and falsehood membership function , $FN : U \rightarrow [0, 1]$, with $0 \leq TN (x)+ IN (x)+ FN (x) \leq 3$

Using neutrosophic scales with single-valued neutrosophic sets, responses are categorized according to the total of the True, Indeterminate, and False components as follows:

- T+I+F<1: Incomplete
- T+I+F=1: Complete
- T+I+F>1: Contradictory

These values are obtained because, in many cases, opinions are incomplete or contradictory. This classification is one of the advantages of using neutrosophic methods, as it allows for a more nuanced understanding of the different degrees of truth, indeterminacy, and falsity in the responses.

3. Proposed framework

To begin, it's essential to clearly define the desired outcome: precisely identify and describe the phenomenon, event, or condition you wish to explore. This step is essential because it establishes the approach and framework that will guide the subsequent analysis.

Next, proceed to develop neutrosophic Likert scales. These scales, in contrast to conventional scales that employ a fixed range of values (such as 1 to 5), incorporate additional dimensions of truth, indeterminacy, and falsity. Instead of simple numerical scores, neutrosophic scales use a triplet (T, I, F) for each option, where T represents the degree of truth, I the degree of indeterminacy, and F the degree of falsity. This method allows for a more nuanced and detailed assessment of participants' responses and perceptions.

Next, collect relevant data on the cases under study, using a variety of indicators or measures related to the defined outcome. It is crucial that data collection be thorough and accurate so that it adequately reflects the variables being analyzed. Use Neutrosophic Likert scales in questionnaires and surveys to obtain a more complete data set that more accurately captures the complexity of respondents' opinions and attitudes.

This detailed and refined approach ensures a deeper and more accurate interpretation of the results, thus facilitating a comprehensive understanding of the phenomenon in question.

Fuzzification : Finally, the obtained neutrosophic sets are transformed into equivalent fuzzy sets, following the procedure described in [17]. This step is essential for the subsequent analysis, allowing to handle the uncertainty and ambiguity inherent in the collected data. Let $AN = \{x, (TA(x), IA(x), FA(x)) : x \in X\}$an NS. Its equivalent fuzzy membership set is defined as $AF = \{(x, \mu A(x)) : x \in X\}$,where $\mu A(x) = s\left((TA(x), IA(x), FA(x)), (1,0,0)\right)$. Then, using the similarity equation proposed in,

$$\mu A(x) = 1 - \frac{1}{2}[(1 - T_A(x)) + \max\{I_A(x), F_A(x)\}] \quad (1)$$

Since the range of the similarity measure function is the unit interval [0,1], μA (x) ∈ [0,1] for all x ∈ X. Therefore, the membership function of the derived fuzzy set belongs to [0,1] and hence satisfies the property of a fuzzy set (FS) membership function.

1 Analysis: Perform fsQCA to identify which combinations of factors or conditions are associated with the presence or degree of the outcome. Data processing is performed using fsQCA for Windows [18, 19].

Configuration validity is assessed by measuring consistency and coverage values. Consistency is the measure of how reliably the set of pathways produces the desired outcome. Coverage refers to the degree to which the outcome is clarified by this arrangement of pathways[20]:

$$\text{Consistency}(X \geq Y) = \frac{\sum(\min(X_i, Y_i))}{\sum(Y_i)} \quad (2)$$

$$Coverage(X \geq Y) = \frac{\sum(\min(X_i, Y_i))}{\sum(X_i)} \quad (3)$$

where :

$X_i$is the membership value of case i in the set of causal conditions.

$Y_i$is the membership value of case iii in the result set.

Both are used in comparative analysis to evaluate the relationships established between individual conditions, combinations of conditions, track configurations, and the final outcome. Generally, values above 0.8 are considered to indicate a strong relationship [20].

4. Results.

Within the framework of this research, the outcome of interest is the **Perceived Employability (PE)** of university graduates. To analyze this phenomenon, three fundamental causal conditions have been established that, according to the literature and the Ecuadorian context, shape the professional profile:

- **Technical Competencies (TC):** Refers to the mastery of knowledge and skills specific to a profession, acquired through formal academic training.

- **Soft Skills (BS):** These encompass a set of personal and social attributes such as communication, teamwork, leadership, and problem-solving, which facilitate effective interaction in the work environment.
- **Alignment with the Labor Market (AML):** Measures the relevance of university education to the current demands, technologies, and dynamics of the productive sector.

To quantify perceptions of these variables, a survey using neutrosophic Likert scales was administered to a panel of 20 experts, composed of human resources directors, academics, and professional development consultants in Ecuador. The collected data, expressed in single-valued neutrosophic sets (T, I, F), are presented below.

Table 1. Neutrosophic Data Collected from Experts

Experts	Technical Competencies (TC)	Soft Skills (HS)	Market Alignment (AML)	Perceived Employability (PE)
1	(0.8, 0.2, 0.1)	(0.9, 0.1, 0.2)	(0.7, 0.3, 0.2)	(0.8, 0.2, 0.2)
2	(0.6, 0.5, 0.3)	(0.7, 0.4, 0.3)	(0.5, 0.5, 0.4)	(0.6, 0.4, 0.3)
3	(0.9, 0.1, 0.0)	(0.8, 0.2, 0.1)	(0.9, 0.2, 0.1)	(0.9, 0.1, 0.1)
4	(0.5, 0.6, 0.5)	(0.6, 0.5, 0.4)	(0.4, 0.6, 0.5)	(0.5, 0.5, 0.5)
5	(1.0, 0.0, 0.0)	(0.9, 0.1, 0.1)	(0.8, 0.3, 0.2)	(0.9, 0.2, 0.0)
6	(0.7, 0.3, 0.3)	(0.8, 0.2, 0.2)	(0.7, 0.4, 0.3)	(0.8, 0.3, 0.2)
7	(0.8, 0.4, 0.2)	(0.9, 0.3, 0.1)	(0.8, 0.3, 0.2)	(0.9, 0.2, 0.2)
8	(0.6, 0.6, 0.4)	(0.7, 0.5, 0.2)	(0.6, 0.5, 0.3)	(0.7, 0.4, 0.3)
9	(0.9, 0.2, 0.1)	(1.0, 0.1, 0.0)	(0.9, 0.2, 0.2)	(1.0, 0.1, 0.1)
10	(0.7, 0.4, 0.4)	(0.6, 0.4, 0.3)	(0.7, 0.5, 0.4)	(0.6, 0.4, 0.4)
11	(1.0, 0.1, 0.1)	(0.9, 0.2, 0.2)	(0.8, 0.3, 0.3)	(0.9, 0.2, 0.1)
12	(0.8, 0.3, 0.2)	(0.8, 0.3, 0.2)	(0.9, 0.2, 0.1)	(0.8, 0.2, 0.2)
13	(0.7, 0.5, 0.3)	(0.7, 0.4, 0.4)	(0.6, 0.5, 0.4)	(0.7, 0.4, 0.4)
14	(0.9, 0.2, 0.2)	(0.8, 0.2, 0.3)	(0.8, 0.3, 0.3)	(0.8, 0.3, 0.2)
15	(0.6, 0.4, 0.4)	(0.7, 0.3, 0.3)	(0.7, 0.4, 0.4)	(0.7, 0.3, 0.3)
16	(0.8, 0.2, 0.3)	(0.9, 0.2, 0.1)	(0.9, 0.3, 0.1)	(0.9, 0.2, 0.2)
17	(0.7, 0.3, 0.4)	(0.8, 0.4, 0.2)	(0.7, 0.4, 0.3)	(0.8, 0.4, 0.3)
18	(0.9, 0.1, 0.2)	(0.9, 0.2, 0.2)	(1.0, 0.1, 0.1)	(0.9, 0.1, 0.2)
19	(0.6, 0.5, 0.5)	(0.7, 0.5, 0.4)	(0.6, 0.6, 0.5)	(0.6, 0.5, 0.5)
20	(0.8, 0.2, 0.1)	(0.8, 0.2, 0.1)	(0.9, 0.1, 0.2)	(0.8, 0.1, 0.2)

Step 1: Fuzzification of Neutrosophic Data

In order to apply comparative analysis, neutrosophic sets are transformed into equivalent fuzzy sets. This process, known as fuzzification , is performed using Equation 1, which integrates the degrees of truth (T), indeterminacy (I), and falsity (F) into a single fuzzy membership value.($\mu A(x)$).

Fuzzification Formula (Equation 1):

This procedure is repeated for all 20 experts' perceptions. The resulting fuzzy values are presented in Table 2.

Table 2. Fuzzification Process

Experts	CT (μ)	HB (μ)	AML (μ)	EP (μ)
1	0.833333	0.866667	0.733333	0.800000
2	0.600000	0.666667	0.533333	0.633333
3	0.966667	0.833333	0.866667	0.933333
4	0.466667	0.566667	0.433333	0.500000
5	1.000000	0.900000	0.766667	0.900000
6	0.666667	0.733333	0.633333	0.733333
7	0.733333	0.800000	0.766667	0.800000
8	0.533333	0.666667	0.600000	0.633333
9	0.866667	0.933333	0.833333	0.933333
10	0.566667	0.633333	0.566667	0.566667
11	0.933333	0.833333	0.733333	0.866667
12	0.766667	0.766667	0.866667	0.800000
13	0.633333	0.600000	0.533333	0.600000
14	0.833333	0.766667	0.733333	0.733333
15	0.600000	0.666667	0.600000	0.666667
16	0.766667	0.866667	0.833333	0.800000
17	0.666667	0.733333	0.633333	0.666667
18	0.866667	0.833333	0.900000	0.866667
19	0.533333	0.600000	0.500000	0.500000
20	0.866667	0.866667	0.866667	0.866667
Addition	**14.700000**	**15.133333**	**13.733333**	**14.800000**

Step 2: Analysis of Necessary Conditions

Next, we assess whether any of the conditions (CT, HB, AML) are necessary for the outcome (EP). To do this, we calculate the **Consistency** and **Coverage parameters** using Equations 2 and 3. A consistency value greater than 0.8 generally indicates a strong and necessary relationship.

As an example, the calculation of consistency and coverage for the **Soft Skills (HB) condition** as a predictor of **Perceived Employability (EP) is detailed** :

1. **Calculate** $\sum \boldsymbol{min}(\boldsymbol{HBi}, \boldsymbol{EPi})$:The minimum value between HB and EP is taken for each of the 20 experts and added together.
   - $min(0.866667, 0.800000) = 0.800000$
   - $min(0.666667, 0.633333) = 0.633333$
   - ... (done for the 20 experts) ...
   - **Sum of Minimums** $\sum \boldsymbol{min}(\boldsymbol{HBi}, \boldsymbol{EPi})$: 14.433333
2. **Obtain Sums of the Columns (from Table 2):**
   - $\sum HBi = 15.133333$
   - $\sum EPi = 14.800000$
3. **Calculate Consistency and Coverage:**
   - **Consistency(HB ≤ EP):** Consistency=$15.13333314.433333 = 0.953741$
   - **Coverage (HB ≤ EP):** Coverage= $14.80000014.433333 = 0.975225$

This process is replicated for all conditions. The results are summarized in Table 3.

Table 3. Analysis of Necessary Conditions for Perceived Employability (PE)

Tested Conditions	Sum of Minima with EP	Consistency	Coverage
Technical Competencies (TC)	13.966667	0.950113	0.943694
Soft Skills (HS)	14.433333	0.953741	0.975225
Market Alignment (AML)	13.166667	0.958730	0.889640
Perceived Employability (PE)	14.800000	1.000000	1.000000

The results show that the three individual conditions have **very high consistency values (over 0.95)** , which qualifies them as necessary conditions for achieving high perceived employability. **Labor Market Alignment (LMA) stands out** with the highest consistency (0.9587), suggesting that the relevance of the curricula is an almost indispensable requirement. **Soft Skills (SS)** obtained the highest coverage (0.9752), indicating that this condition explains the largest proportion of the result.

Step 3: Set Matching Analysis

This analysis explores how combinations of conditions relate to the outcome. The consistency of the intersection (logical AND operator, implemented with the min function) of the sets of conditions against perceived employability is calculated.

Table 4. Condition Set Matching Analysis

Conditions (Logical AND Combination)	Consistency
CT * HB * AML	0.977841
CT * HB	0.968605
CT * AML	0.971292
HB * AML	0.976378

Note: *The match is calculated as the consistency of the combined configuration. For example, for CT* HB*AML, the formula is$\sum min(CTi, HBi, AMLi)/\sum min(CTi, HBi, AMLi, EPi) *$

The highest coincidence value is observed in the combination of the three conditions (**0.9778**), which indicates that the synergistic interaction of Technical Competencies, Soft Skills and Alignment with the Labor Market presents the most robust and consistent relationship with Perceived Employability.

Superset and Configuration Analysis

Finally, Table 5 summarizes the consistency and coverage values for all individual conditions and their combinations, allowing a direct comparison of the different paths leading to the outcome.

Table 5. Results of Superset /Subset Analysis

Terms (Settings)	Consistency	Coverage
CT * HB * AML	0.977841	0.875000
CT * HB	0.968605	0.916667
CT * AML	0.971292	0.891892
HB * AML	0.976378	0.898649
CT	0.950113	0.943694
HB	0.953741	0.975225
AML	0.958730	0.889640

This final analysis confirms that, while all conditions are individually necessary and consistent, the **combinations of conditions** (especially HB*AML and the triple combination) achieve the highest levels of consistency. However, coverage does not always increase with configuration complexity. The **CT*HB combination** presents very high coverage (0.9167), suggesting that the combination of technical and soft skills is a pathway that explains a large proportion of high employability cases, even without perfect market alignment.

5. Discussion

The results obtained offer a detailed and multifaceted view of the factors that shape the employability of graduates in Ecuador. The main finding is that no condition operates in isolation; on the contrary, the **synergistic interaction** between Technical Competencies (TC), Soft Skills (SS), and Labor Market Alignment (LMA) constitutes the most robust configuration for predicting Perceived Employability (PE), reaching a consistency of **0.9778** . This result aligns with complexity theory, which postulates that outcomes emerge from the conjunction of multiple interdependent factors.

A notable aspect is the very high consistency score of all individual conditions (all > 0.95), which establishes them as **necessary conditions** in the Ecuadorian context. This contrasts with studies in other contexts (e.g. , López, 2022), where technical skills alone do not always reach such high thresholds of need. The high consistency of the AML (0.9587) is particularly revealing for the Ecuadorian higher education system, as it suggests that **curricular relevance** is not a desirable factor, but an indispensable requirement for employability.

The Soft Skills **coverage** (0.9752) was the highest among the individual conditions, indicating that this factor alone "covers" or explains most cases of high employability. This finding reinforces the growing demand of the global labor market, which increasingly prioritizes socio-emotional skills over purely technical ones (World Economic Forum, 2023).

The configuration analysis (Table 5) reveals that, although the combination of the three factors is the most consistent, the combination of **Soft Skills and Market Alignment (HB*AML)** also presents very high consistency and coverage (0.9764 and 0.8986, respectively). This suggests a strategic path for universities: even if updating technical competencies is a slower process, a strong focus on soft skills and engagement with the productive sector can have a significant impact on employability.

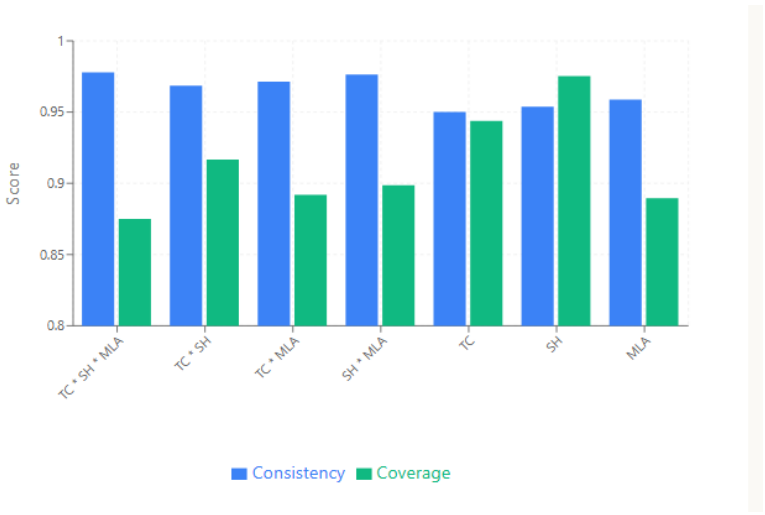

Figure 1: Consistency and Coverage Analysis for Perceived Employability Configurations

Limitations and Future Research: This study, while methodologically robust, has limitations. The sample of 20 experts, although qualified, is small and may not capture the full diversity of opinions at the national level. Future research should expand the sample to include the perspectives of students and recent graduates themselves. Furthermore, this analysis is static in nature; a longitudinal study could track how the relative importance of these factors changes over time and with labor market transformations. Finally, the fsQCA methodology , although powerful, does not establish directional causality. It would be beneficial to complement these findings with qualitative methods that explore underlying causal mechanisms.

6. Conclusions

This study successfully applied a framework based on neutrosophic set theory and comparative qualitative analysis to unravel the complex relationships among the factors that determine the employability of university students in Ecuador. Clear conclusions were reached with direct practical implications for educational policy and university strategy.

1. **Interdependence and Synergy:** The main conclusion is that Perceived Employability is not the result of a single factor, but rather the **synergistic combination of Technical Competencies, Soft Skills, and Alignment with the Labor Market** . The configuration that combines these three elements demonstrated the highest consistency (0.9778), validating a comprehensive and multifactorial approach to vocational training.
2. **The Inevitable Need for the Three Factors:** Contrary to a traditional view, the analysis showed that the three conditions studied are, in and of themselves, **necessary conditions** for professional success in the Ecuadorian context, with consistency values above 0.95. This sends a strong message to higher education institutions: neglecting any of these three areas critically impacts the profile of their graduates.
3. **Practical Primacy of Soft Skills:** Soft skills are not only a necessary condition, but also the ones with the greatest **coverage (0.9752)** . This means they are the factor that best explains the perception of employability in most cases. For universities, this implies that investing in communication, leadership, and teamwork development programs is one of the most effective strategies for enhancing the professional profile of their students.
4. **Strategic Implications for Higher Education:** The findings offer a roadmap for decision-making. Universities should:
    - **Reform curricula** to ensure constant alignment with the demands of the productive sector.
    - **Integrate soft skills development** across all majors, not as isolated workshops.
    - **Strengthen strategic alliances** with companies to ensure that the technical skills taught are those required in practice.

In summary, this study overcomes a simplistic view of vocational training and provides a nuanced model that reflects the complexity of today's labor market. By using a neutrosophic methodology, it has been possible to address the uncertainty and ambiguity inherent in human perceptions, offering a solid empirical basis for Ecuadorian universities and *policymakers* to design more effective and holistic interventions, better preparing future professionals for the challenges of a dynamic market.

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